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Giant earthworms build up vermic mountain rendzinas

ABSTRACT

Rendzinas developing on insularly distributed limestone areas covered by beech or beech-hornbeam forests in the Carpathians are inhabited by peculiar earthworm communities in which giant lumbricid species like *Octodrilus frivaldskyi* or *Allolobophora robusta* (length 60-100 cm, fresh weight 20-50 g) are dominant. The high food supply, the chemical and microclimatic conditions generated by the calcareous rocks result in earthworm synusia with a high biomass (150-250 g·m^{-2}) and rich in species of different ecological types. Besides the giant endogeic species, there usually occurs one of the medium-sized species such as *A.mehadiensis, A.sturanyi, O.exacystis* or *O.compromissus*, as well as smaller epigeic species like *Dendrobaena byblica, D.clujensis, D.rubida* or *Lumbricus rubellus*.

These worms, particularly the giant ones, contribute to the formation of very large and stable soil aggregates, imprinting the vermic diagnostic characters of the rendzina. In this study pore spaces, size distribution of aggregates are analysed by structure photograms and microphotos on thin sections of the soil. Mineral, organic and organo-mineral coprolites (worm casts or their residues) are described.

Key-words: Earthworm casts, Oligochaeta.

1. Introduction

The role of earthworms in forming soil aggregates is one of the best known aspects of their activity. Accordingly, the literature on this subject is very extensive, and shall not be considered here. Valuable synthetic information is given by Satchell (1967) and Edwards & Lofty (1972). Closer to our theme are the works of Zachariae (1965), Hartmann (1965), Lamparski and Kobel-Lamparski (1987).

In soil science, since the «7th American Approximation» (1960) the term *vermic* has indicated soils intensively processed by soil fauna, especially by earthworms, with a granular or crumb structure, in more than 50% of humiferous A, AC or even in B horizons.

We do not intend to discuss the suitability of this term, but we suggest that perhaps it was not quite the best term. It should be stressed that, by definition, a normally developed soil must be *vermic*, i.e. developed by the participation of different earthworms and other taxa of soil fauna. In this respect, when defining mull, Kubiena (1953) states: «Practically all aggregates are earthworm casts or residues of them». This statement should be extended, because the traces of the activity of soil fauna, especially of earthworms can be proved micromorphologically on the entire profile of most soil types. So, in our opinion, the term *vermic* should be used to indicate visible, macromorphologically stable and lasting aggregates build up by soil fauna. We ourselves have used this term in the very title of the present paper that concerns a peculiar vermic soil, namely a rendzina which acquired, in our opinion, the best developed vermic features to be found in the zoogeographic area of the Lumbricidae.

We shall present here only the earthworm-connected aspects of the issue, the pedological ones (nomenclature, description of soil profile, physical and chemical properties) are being prepared for publication on a separate paper.

2. Material and Methods

2.1 *Site*

Rendzinas occur in insularly distributed limestone or dolomite karstic areas of the Romanian Carpathians under forest or meadow vegetation.

The paper deals with the particular case of a rendzina under a beech forest (As. *Symphyto cordati-Fagetum* Vida 1959, facies with *Allium ursini*) situated in the Padis karstic region (the Bihorului Mts, the Apuseni Mountains) at 1300 m altitude, S-SV aspect, 20% slope. It is a well developed forest in its climax state.

The soil is a cambic rendzina with calcic mull and the profile of the type: 0 (3-0 cm), Am (0-25 cm), AmBv (25-36 cm), BvR (36-46 cm) and R (46 cm+).

2.2 *Methods*

The structure of the earthworm synusia was established by monthly samplings in 1979 with 0.1% formalin. The earthworm biomass was estimated by weighing the worms preserved in 4% formalin.

Photograms (×5) of natural soil structure were produced on thin sections of the soil, sampled

undisturbed in large (8×6×4cm) metallic boxes. The microphotos were made by the polarising microscope (×150).

3. Results and Discussion

3.1 *The earthworm synusia*

The earthworm synusia inhabiting the rendzina from Padis has 5 species (Tab. I). It is an ecologicaly well balanced synusia, with the highest biomass recorded in the Romanian Carpathians (257 $g \cdot m^{-2}$).

It should be mentioned that this type of synusia could differ in specific composition from one calcareous island to another, although they apparently have similar vegetation and soil (rendzinas and the related Terra rossa or Eutrophic Brown Soils). Nevertheless, a certain functional or ecological pattern of synusia is preserved by a process of substitution of ecologically similar species.

Thus, the giant endogeic species of the *Octodrilus* genus like *frivaldskyi, racovitzai, robustus* and *Allolobophora robusta* are vicariants, but one of them is always present.

Besides the endogeic and probably vertical migrator giant species, there usually occur medium-sized endogeic species such as *Octodrilus exacystis, bihariensis, compromissus, Allolobophora mehadiensis* or *sturanyi*, and smaller epigeic ones like *Dendrobaena byblica, clujensis, rubida* or *Lumbricus rubellus*.

In most places there also occurs the large vertical migrator *Lumbricus polyphe-*

TABLE I - *The structure of earthworm synusia in the vermic cambic rendzina from Padis**.

Species	Density ($N \cdot m^{-2}$)		Biomass ($g \cdot m^{-2}$)	
	Mean	Range	Mean	Range
Octodrilus frivaldskyi (Örley) 1880	4.6	1.8 – 8.9	93.6	25.0 – 204.0
Octodrilus bihariensis V.V.Pop 1986**	2.7	0.8 – 5.3	14.2	3.9 – 23.4
Octodrilus sp. (juveniles)	7.4	4.0 – 18.2	8.3	5.3 – 19.9
Dendrobaena alpina (Rosa) 1884	3.7	0.4 – 8.0	0.1	0.1 – 0.2
Dendrobaena byblica (Rosa) 1893	6.3	2.7 – 14.7	1.5	0.7 – 3.0
Dendrobaena clujensis Pop 1938	9.0	40 – 13.8	9.3	3.0 – 15.8
Earthworm synusia as a whole	33.0	21.2 – 65.7	127.0	53.6 – 256.6

* Mean values of monthly recordings between May-November 1979.

** In press.

mus, a fact that led us to give its name to this synusia type (Pop, 1982). As we did not find it in the Padis area, we consider its absence due to the lack of hornbeam litter.

3.2 *The vermic structure of the soil*

All cohabiting earthworms must have soil forming activity, but the most evident and quite unusual traces are produced by the giant ones.

The most particular feature of this rendzina is the presence of a distinct surface layer, about 4 cm thick, of earthworm casts. These casts, of 1-3 cm in diameter, are not linked or united together. Under the feet they feel like a stratum of rolling balls or wallnuts.

Among the old rather hardened ones, there are some fresh earthworm castings. Those of the giant worms have specific conical aspect (Fig. 1). Such a fresh cast, excreted in a single night, can weight as much as 200 g (oven dried).

Fig. 1 – *Octodrilus frivaldskyi* castings.

More reliable evidence of the high vermic character is shown in a series of structure photograms of the soil profile to the depth of 40 cm; the presence of hard rocks hindered us from sampling deeper (Fig. 2-12).

In all structure photograms 3 types of worm-casts or coprolites can be distinguished, those constisting of, (a) mineral material brought up by worms from deeper horizons, (b) organic material – vegetal remnants in different degrees of breakdown, in some plots replaced by casts or microaggregates of mesofauna, and (c) organo-mineral caprolites of deeper material mixed with organic ones ingested by the worms.

The surface structure is also shown in 2 microphotos. The first one shows an organic coprolite where we notice slightly broken-down vegetal material, fine humus, and isolated mesofauna aggregates. Microphoto 2 is the magnified spot of a mineral coprolite where we notice ferrimanganic nodules. These photograms show the very aerated crumb, porous structure of the surface soil horizons, constituted almost entirely by wormcasts, with large spaces among them. In

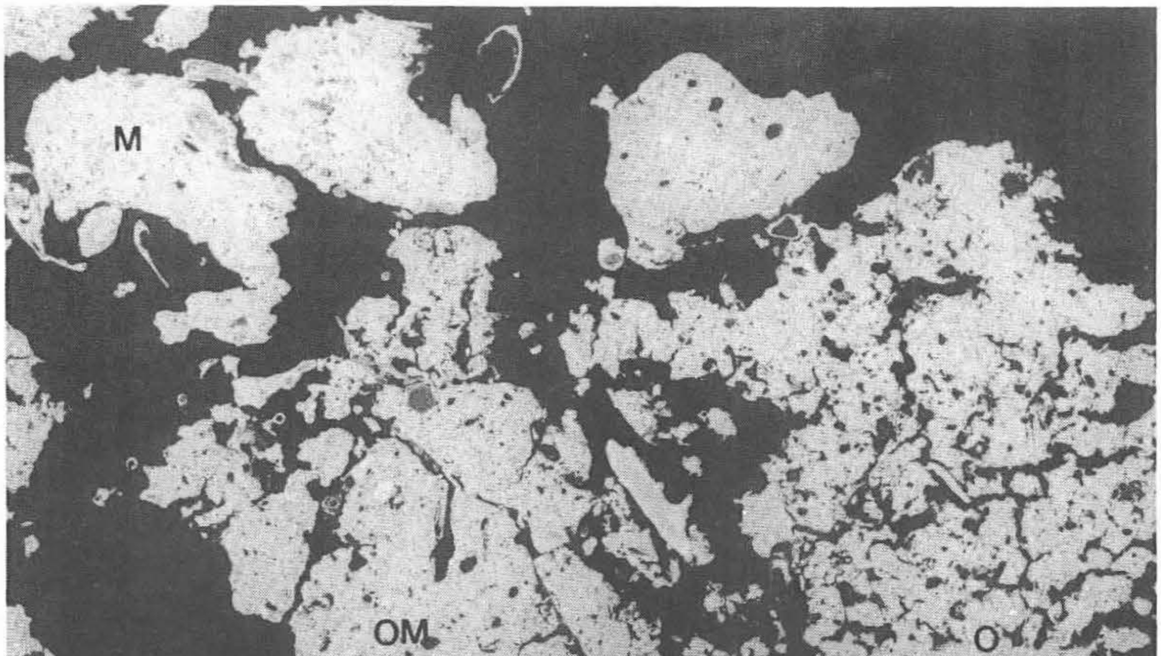

Fig. 2 – Structure photogram (×5) of Am horizon (0-4 cm).
M – mineral coprolites
OM – organo-mineral coprolites
O – organic coprolites

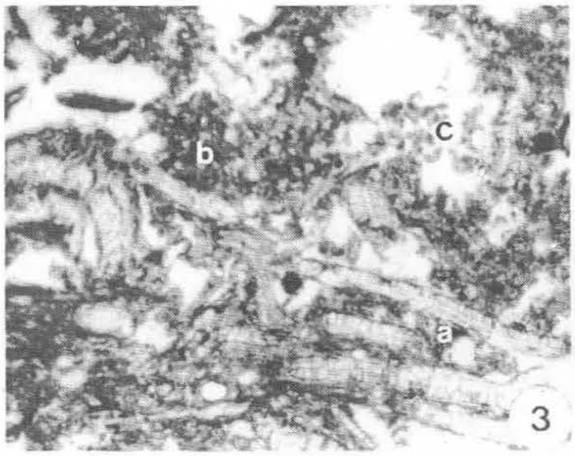

Fig. 3 – Microphoto (×150) of an organic coprolite in Am horizon (0-4 cm).
a – slightly broken down vegetal remnants
b – fine humus
c – isolated zooaggregates of mesofauna

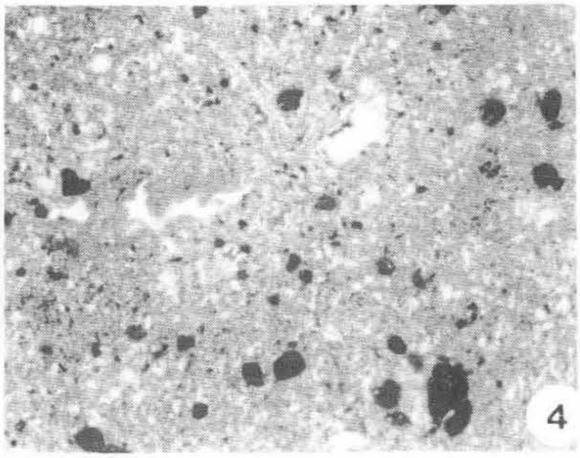

Fig. 4 – Microphoto (×150) of a mineral coprolite in Am horizon (0-4 cm). Ferric clay plasma with dissipated ferri-manganic nodules.

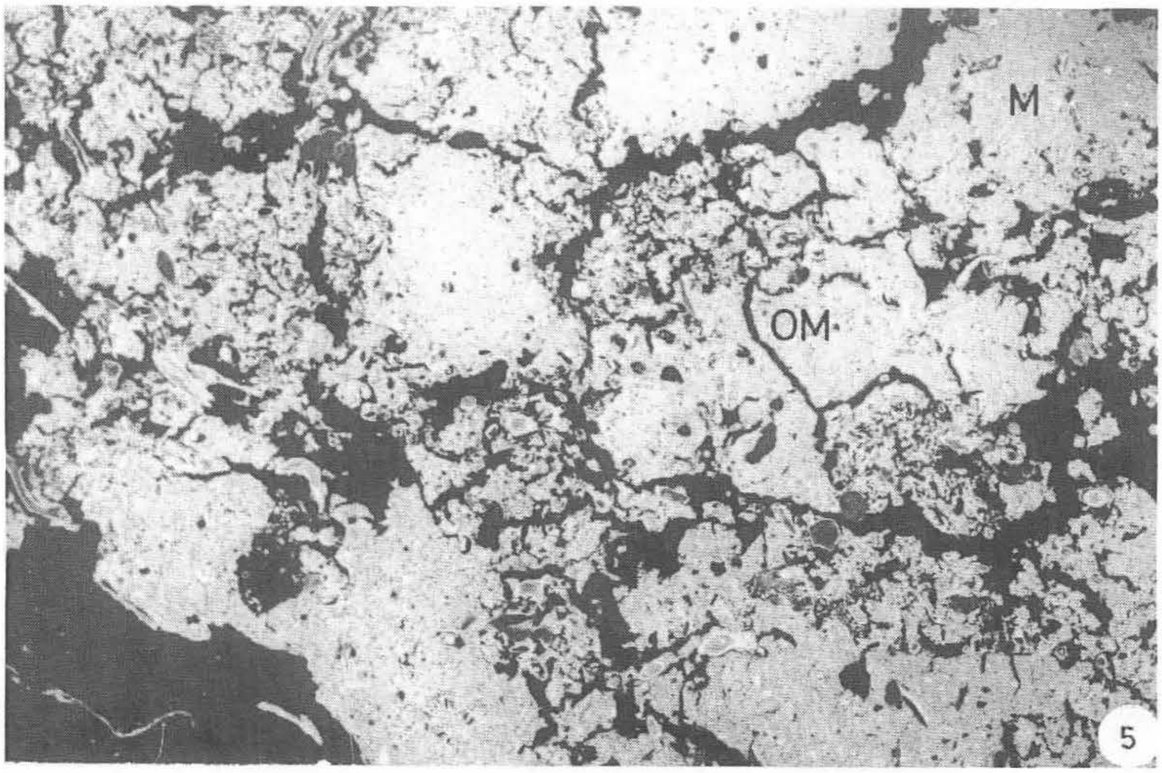

Fig. 5 – Structure photogram (×5) of Am horizon (4-8 cm).

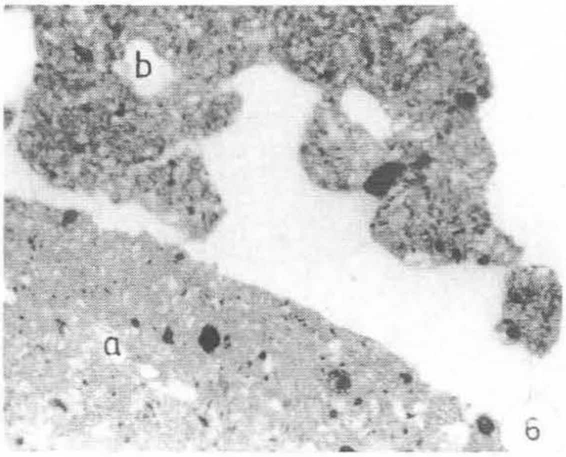

Fig. 6 – Microphoto (×150) of a mineral coprolite in Am horizon (4-8 cm).
a – mineral matter
b – zooaggregates of mesofauna

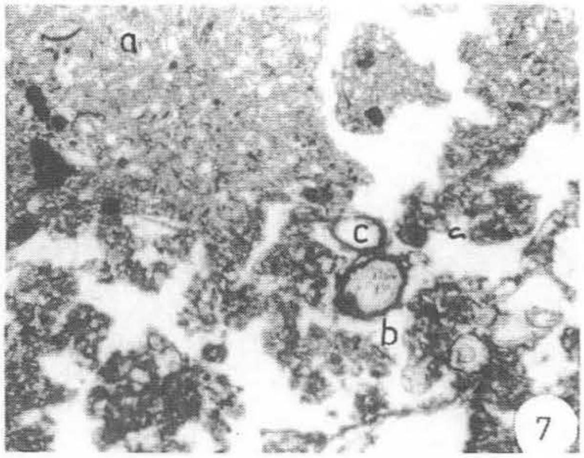

Fig. 7 – Microphoto (×150) of an organic coprolite in Am horizon (4-8 cm).
a – mineral matter
b – zooaggregates of mesofauna
c – vegetal remnants

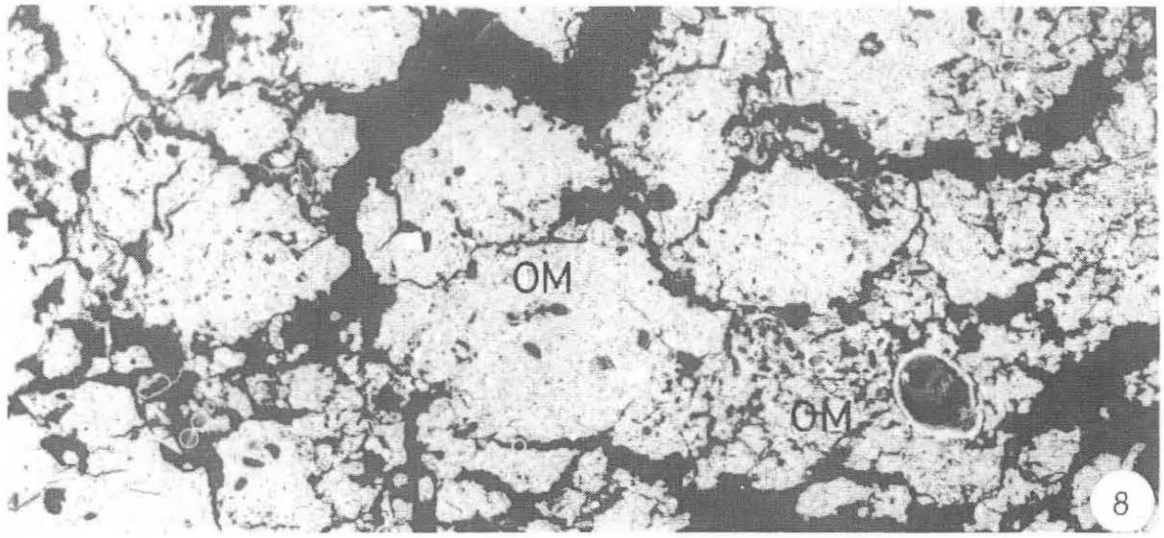

Fig. 8 – Structure photogram (×5) of Am horizon (8-165 cm).
OM – organo-mineral coprolite

deeper soil horizons, the casts are more and more pressed together and the porous spaces smaller.

In the upper soil horizons a sponge-like microstructure dominates, due to

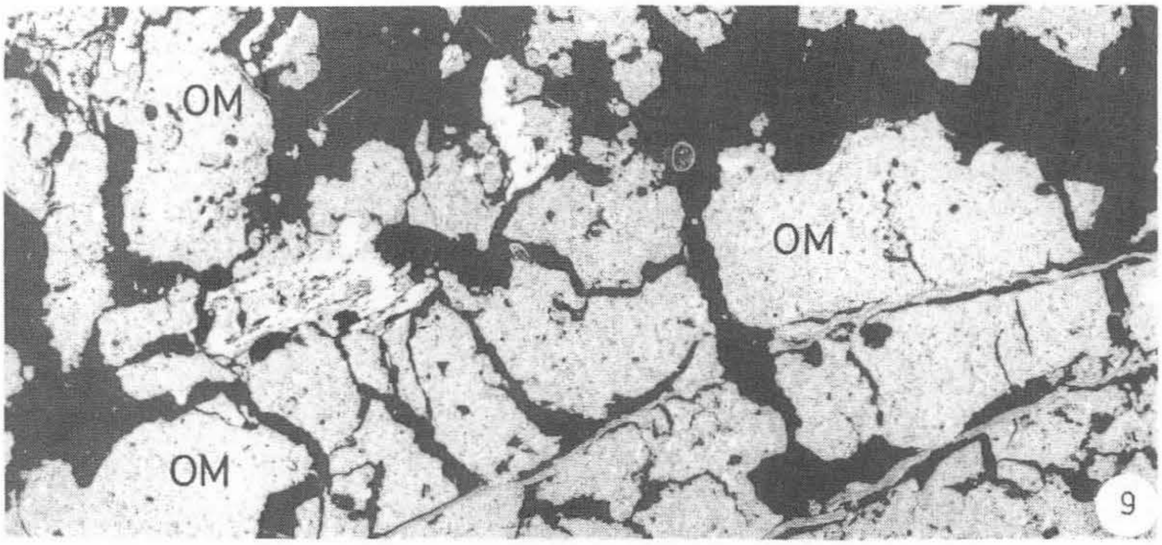

Fig. 9 – Structure photogram (×5) of AmBv horizon (16-24 cm).

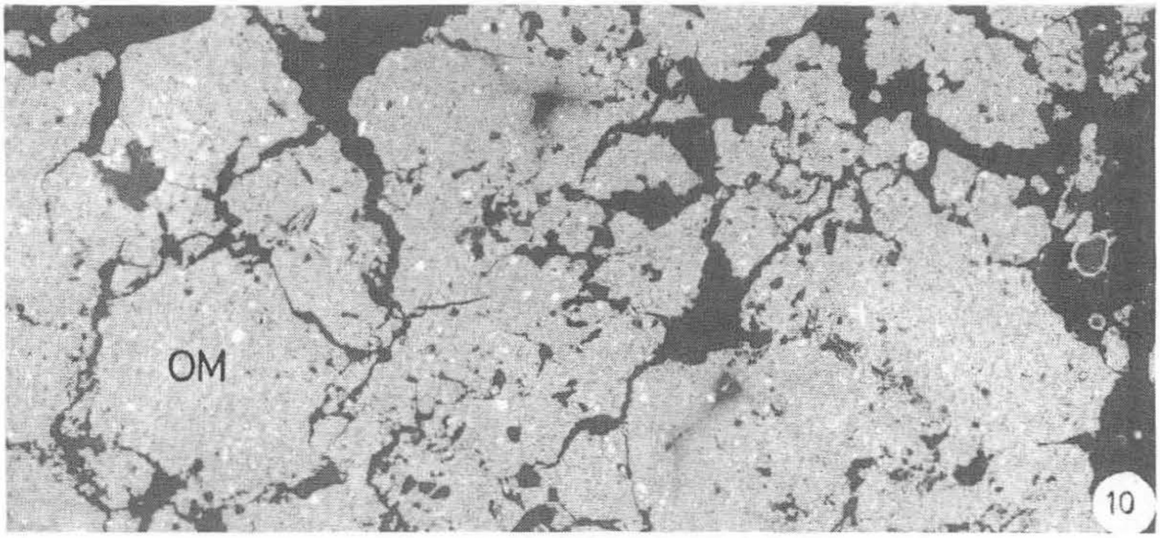

Fig. 10 – Structure photogram (×5) of Bv horizon (24-32 cm).

the activity of mesofauna. The earthworm casting, being rich in organic matter, is a suitable medium for the development of mesofauna.

Large amounts of soil material from deeper horizons are brought to the surface and deposited as casts and thus the formerly surface casting horizons are buried. Their secondary and tertiary comminution is achieved by a series of smaller and smaller soil dwellers (animals, fungi and bacteria) as well as by physicochemical weathering. The organic remnants brought into the soil by

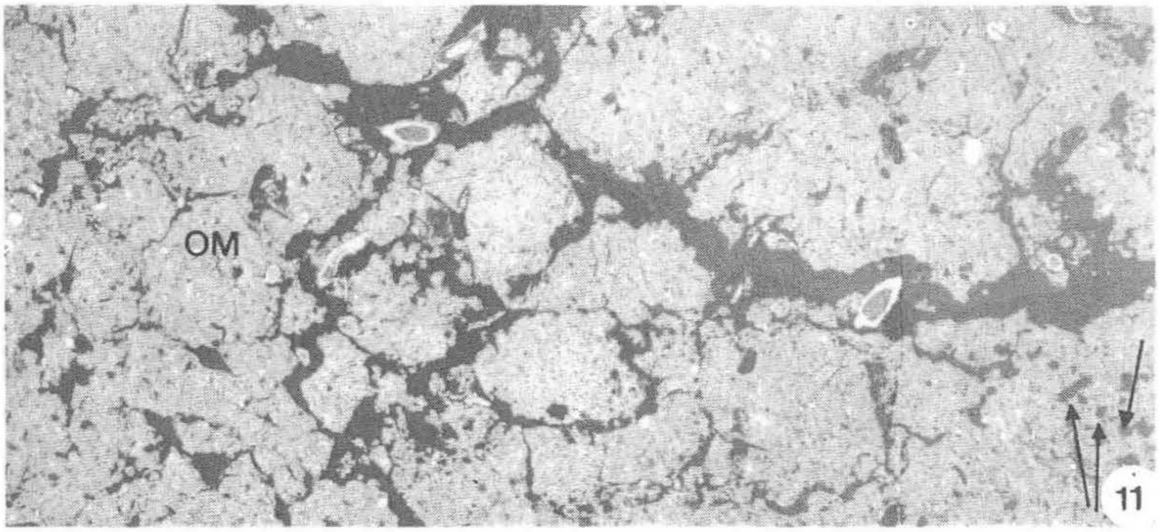

Fig. 11 – Structure photogram (×5) of BvR horizons (32-40 cm). Arrows indicate spongy structure with isolated hollows.

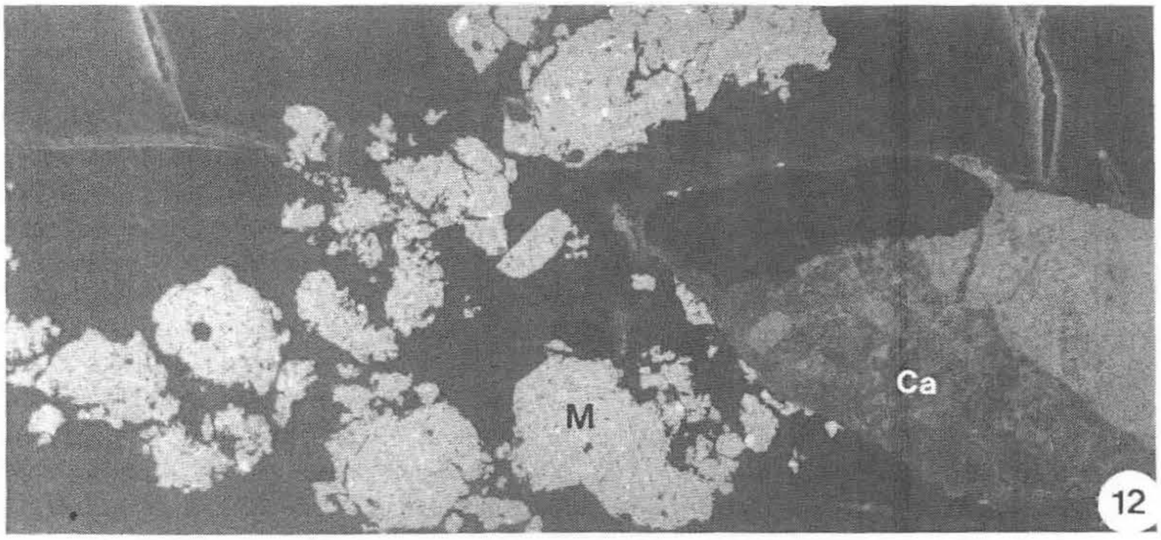

Fig. 12 – Structure photogram (×5) of isolated fragments from the BvR horizon (40-50 cm).

M – mineral coprolites
Ca – limestone fragment

worms, with an initial recognizable tissue structure, gradually turn into «fine humus».

In the deeper horizons the diameter of worm casts is smaller than at the surface. The sponge-like microstructure of mesofauna diminishes and the

horizons appear more compact. However, the worm-cast structure does not totally disappear even in the deeper horizons.

4. Conclusions

The formation of this highly vermic rendzina seems to be connected to three factors, namely: (1) the occurrence of limestone or dolomite karstic islands in the Carpathians; (2) the presence of beech-hornbeam or beech forests; and (3) the soil inhabiting earthworm community with the largest known lumbricids, such as *Octodrilus frivaldskyi* or *Allolobophora robusta* (60-100 cm length and 20-50 g fresh weight).

The earthworm synusia with the giant *Octodrilus* or *Allolobophora* species undoubtedly build up rendzinas (and related Terra rossa and Eutrophic Brown Soils) of the highest vermic feature in karstic areas, a fact that seems to justify the separation of a «vermic» rendzina subtype, and maybe of a new and very peculiar kind of ecosystem (Pop, 1983).

REFERENCES

Edwards C. A., J. R. Lofty, 1972 – Biology of Earthworms. Chapman and Hall Ltd, London.

Hartmann F., 1965 – Waldhumusdiagnose auf biomorphologischer Grundlage. Springer, Wien, New York.

Kubiena W. L., 1965 – The Soils of Europe. Murby, London.

Lamparski F., A. Kobel-Lamparski, 1987 – Comparison of the burrows of *Lumbricus badensis* and *Lumbricus polyphemus*. This volume, 131-140.

Pop V. V., 1982 – Asupra lumbricofaunei fagetelor carpatine (On the Carpathian Beech Forests Earthwormfauna). *In*: Les hêtraies Carpatiques. Leur signification biohistorique et écoprotective. Trav. Sympos. 30-31 mai 1979. Acad. R. S. Roumanie, Souscommission pour la protéction des monuments de la nature. Cluj-Napoca, pp. 327-341.

Pop V. V., 1983 – Importanta conservarii edafobiontelor endemice din Carpatii romanesti. Ocrot. nat. med. înconj. t. 27, *1*, 37-39. Buc.

Satchell J. E., 1967 – Lumbricidae. *In*: Burges A. and F. Raw (ed.) Soil Biology, 259-318.

Zachariae G., 1965 – Spuren tierischer Tätigkeit im Boden des Buchenwaldes, Paul Parey, Hamburg.

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